

# The Biennial Report

OF THE

## Board of Geological Survey

OF THE

State of Washington

FOR THE TERM 1915-1917



OLYMPIA, WASH.

FRANK M. LAMBORN



PUBLIC PRINTER

1917

## LETTER OF TRANSMITTAL.

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*To the Legislature of the State of Washington:*

The Board of Geological Survey transmits herewith its biennial report for the term 1915-17, as required by statute.

Respectfully submitted,

ERNEST LISTER, *President*;  
LOUIS F. HART,  
EDWARD MEATH, *Secretary*;  
HENRY SUZZALLO,  
ERNEST O. HOLLAND.

Olympia, December 28, 1916.

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# BIENNIAL REPORT OF THE BOARD OF GEOLOGICAL SURVEY

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## GENERAL PURPOSES OF SURVEYS.

### TOPOGRAPHIC SURVEYS.

*The Topographic Map.*—A topographic map is designed to represent the form and slope of the surface of the land and the elevation of all points above sea level. The positions of streams, lakes and ponds, public and private roads, towns and railroads, are shown in their correct relative positions. The map indicates boundaries of counties and the position of section lines wherever there have been land surveys. In the making of the necessary surveys for such maps permanent marks, consisting of iron posts, copper bolts or tablets, are set at frequent intervals to mark the exact elevation above sea level to serve as datum points for further spirit level work, for engineering investigation, and for such public works as canals, water supply, railway and other public or private surveys.

The topographic map is made with such accuracy and in such detail that it is useful to almost every citizen. In a new state that is inviting immigration, the map is valuable in order to show the location of desirable farm lands and the general character of the country. From it the positions of streams and lakes may be seen and the possibilities of these for purposes of water power or irrigation may be largely determined. The topographic map facilitates the construction of railroads and wagon roads, since upon it available routes and grades may be laid out without the preliminary surveys ordinarily necessary for improvements of this kind. In our public schools such a map is indispensable in that it places before the children truthful maps of our commonwealth, instead of those that are glaringly inaccurate.

In the making of topographic maps the areas selected for survey are defined by lines of latitude and longitude and are

called quadrangles. Each quadrangle, and the topographic map which represents its features, is designated by the name of the most prominent place or topographic feature included within it. The scale generally used in map construction is about two miles to the inch, and on this scale the area embraced in a quadrangle is about eight hundred square miles. In Washington, the topographic map when completed will comprise, in round numbers, ninety sheets, complete and fractional, of which about thirty-eight have already been surveyed.

#### HYDROMETRIC SURVEYS.

Hydrometric surveys furnish a basis for determining the water resources of the state. They are essential to indicate the supply of water suitable for domestic and industrial purposes, for comprehensive development of power and irrigation projects, for navigation and flood prevention, and for wise and equitable sanitary regulation. The water supply is of more importance to the life and pursuits of the people than any other natural resource, as the health and economic development of every community are directly dependent upon the character and volume of the available supply.

Our water resources are unlike the other mineral resources in that they are continually existent. Our coal beds and mineral lodes are exhausted when mined and placed upon the market, but the water supply is constantly renewed. Therefore, failure to put water into beneficial use is an economic loss, for the energy and utility does not serve the needs of civilization effectively prior to hydraulic development.

When estimates and designs for hydraulic development are made, all essential physical details, except the stream flow, can be determined within a relatively short time. The amount of water available and its seasonal distribution can be ascertained only by a study of stream flow records extending over a series of years. Many irrigation and power projects have failed on account of being placed in operation without an adequate knowledge of stream flow. Others designed upon the basis of short time records have levied an enormous toll upon the public

through high rates made necessary by unexpected seasonal variation in flow. The run-off for streams in Washington is extremely irregular, especially in respect to the minimum flow which is the most important in considering the operation of any project. For instance, the low water period in August and September of 1915 was much lower than any other on record, likewise the lowest period in 1916 occurred in October and November, when the flow was nearly as low as in August and September, 1915, but was later in the season than shown by any previous records. Aside from the design and operation of irrigation and power projects, stream flow records are vitally essential in considering means of preventing damage from floods. Occasionally "Chinook" winds accompanied by heavy rains melt the snow in the mountains, causing disastrous floods in the lowlands. The last serious flood of this kind occurred in 1906. Unfortunately few records of stream flow were being kept then, so that very meager information is available for designing protective works, although more complete records on streams flooded less seriously in 1909 are very useful.

Hydrometric surveys cover two fields of investigation, the surface supply and the underground supply. The surface supply furnishes by far the greatest volume of water and is readily accessible in the various rivers and creeks. Gaging stations are maintained along the principal streams of the state for determining the daily flow throughout a series of years. Daily records are published and are used extensively in designing hydraulic works of all kinds. Probably the greatest ultimate benefit derived from the streams in the state will be brought about by hydro-electric development. Washington ranks first among the states in the union in respect to estimated potential water-power.\*

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\* A report of the Commissioner of Corporations for March 14, 1912, pp. 55-56, summarizes the potential water power in each state. Washington is credited with a "minimum" potential water power of more than a million horsepower greater than for any other state. The three states having the greatest "minimum" potential water power are as follows: Washington, 4,932,000 horsepower; California, 3,424,000 horsepower; and Oregon, 3,148,000 horsepower.

The possibilities for water power development are being investigated as rapidly as possible. The records of flow indicate water supply. River profiles or level lines along the principal power streams indicate the fall, dam sites, reservoir sites, and other pertinent data. An analysis of the information is being made in a series of seven reports on the water powers of the Cascade Range, three of which are published and a fourth in preparation. These reports summarize the most reliable information obtainable and will greatly encourage hydro-electric enterprise.

Investigation of underground water supplies is equally as important as in the case of surface waters. This work includes a determination of the areas that are underlaid by water-bearing strata, of the depths at which these strata occur, and of the amount and quality of water that may be obtained. A knowledge of the existence of water-bearing strata is very necessary, not alone for the purpose of irrigation, but in some parts of Washington settlement is well-nigh impossible because not even enough water for domestic purposes has as yet been obtained.

#### GEOLOGICAL SURVEYS.

Geological surveys have been organized in nearly all the states of the Union, and in some of the older states they have been continuously active for over fifty years. In most states they are regular departments of the state government, and receive definite financial support in the way given to every other bureau or department. They are usually in charge of a board of three or five men, who direct the work of the survey, and who are responsible for its management.

The general purpose of a geological survey is to disclose and make known the mineral resources of a state. Under such heading would naturally come the metalliferous deposits, coal fields, iron ores, building stones, soils, clay beds, road materials, water power, and kindred subjects. The field work of a survey consists in mapping accurately the locations of all such valuable products as those just mentioned, and determining the areal extent and quantity of each. The office work consists of careful

tests and analyses of all samples collected in the field, and the preparation of reports which describe fully the mineral resources under investigation. The reports and maps when published are valuable alike to the citizens of the state and to outside capitalists and investors. Surveys examine and test those minerals, ores and rocks that are but little known and determine whether or not they are of economic value. They also suggest ways of preventing waste in mining operations, and assist in all ways to conserve the natural resources. Surveys are potent factors in making available valuable information regarding the mineral resources of the state, which knowledge may be utilized by the poorest citizen as well as the wealthiest corporation.

#### PRINCIPAL FEATURES OF STATE LAWS PROVIDING FOR SURVEYS.

The law establishing a state geological survey was passed by the legislature at the session of 1901. As set forth in the various sections of the law, the principal objects of the measure are as follows: An examination of the economic products of the state, such as gold, silver, copper, lead, and iron ores, as well as building stones, clays, coal, and all mineral substances of value; an examination of the soils, road-building material, water supplies, artesian wells, water power, etc.; an examination of the physical features of the state with reference to their practical bearing upon the occupations of the people; the preparation of special geographic and economic maps to illustrate the resources of the state; and the publication from time to time of the results of the work of the survey in reports and bulletins, and the dissemination of these among the people.

At the session of 1903 the legislature amended the above law, by providing for cooperative work between the federal and the state bureaus engaged in geological survey work. The amendment authorized the state board of geological survey to make provisions for topographic, geologic, and hydrometric surveys of the state, in cooperation with the United States geological survey, in such manner as would be of the greatest benefit to the agricultural, industrial and geological requirements of the

state. The amendment carried a proviso that the director of the United States Geological Survey should agree to expend on the part of the United States upon such surveys a sum equal to that expended by the state.

At the session of the legislature for 1909 the work of the state geological survey was provided for by a law having these provisions:

SECTION 1. In order to complete the topographical map of the State of Washington, and for the purpose of making more extensive stream measurements, and otherwise investigating and determining the water supply of the state, there is hereby appropriated the sum of thirty thousand dollars (\$30,000), for cooperation with those branches of the United States Geological Survey engaged in this work. This appropriation, however, shall be contingent upon, and not become available unless the United States government apportion an equal amount to be expended for similar purposes within the state. The board of geological survey is hereby authorized and directed to enter into such agreements with the director of the United States Geological Survey as will insure that the said surveys and investigations be carried on in the most economical manner, and that the maps and data be available for the use of the public as quickly as possible.

SEC. 2. In order to enable the board of geological survey to carry on investigations authorized by law, there is hereby appropriated the sum of twenty thousand dollars (\$20,000) for the use of said board in the geological and other investigations provided for in chapter 165 of the Session Laws of the State of Washington for 1901, and as amended in chapter 157 of the Session Laws of 1903.

SEC. 3. In order to carry out the purposes of this act, all persons employed hereunder are authorized to enter and cross all lands within the state: *Provided*, That in so doing no damage is done to private property.

SEC. 4. The sum of fifty thousand dollars (\$50,000) herein appropriated for the purposes specified in this act shall be available in the following manner: One-half during the first twelve months after this act takes effect, and the unexpended balance during the second twelve months after this act takes effect.

## REPORT FOR 1915-17.

## ORGANIZATION.

The State Board of Geological Survey consists of the following members: Governor Ernest Lister, President; Lieutenant Governor Louis F. Hart; State Treasurer Edward Meath, Secretary; President Henry Suzzallo, of the State University; and President Ernest O. Holland, of the State College. The State Geologist is Professor Henry Landes, who has his office at University Station, Seattle. In cooperation with the United States Geological Survey the Director of that organization is represented by Thomas G. Gerdine, Geographer in Charge, Northwestern Division; and Glen L. Parker, 406 Federal Building, Tacoma, District Engineer.

## TOPOGRAPHIC SURVEYS.

The accompanying progress map indicates the location of the quadrangles surveyed during this biennium, as well as from 1909 to 1915. In selecting quadrangles for survey it has been the policy of the board to choose those areas where the demand for the maps is very great and where they are most likely to be used to advantage.

Since the last biennial report was made the following topographic sheets have been engraved and are now ready for use: Arlington, Chehalis, Coyote Rapids (formerly called the Haven sheet), Hoquiam, Ocosta, and Wenatchee. The following topographic sheets are in the engravers' hands and will soon be ready for distribution: Malaga, Pasco, and Priest Rapids (formerly called the Mitchell sheet).

During the field season of 1915 the topographic mapping was done on the Prosser and Wallula quadrangles. Upon these maps the office work has been completed and they are now ready for the engraver. The field season of 1916 was spent on the Walla Walla and Connell quadrangles, and these areas were completed. The four quadrangles just mentioned were chosen for topographic mapping in order to render assistance to irrigation projects which will be necessary in order to utilize large portions of the arid region. The Connell quadrangle was sur-

veyed in order to render assistance to the dry farming experiment station of the State College which has recently been established at Lind.

Copies of all engraved topographic maps may be purchased of the United States Geological Survey, Washington, D. C., at ten cents each, or at six cents each in lots of one hundred or more.

### HYDROMETRIC SURVEYS.

The water resources of the state have been investigated jointly by the federal and state surveys, each party contributing equal sums. The work is directed from a district office of the federal Survey, located in the Federal Building at Tacoma. In addition the federal Survey maintains gaging stations on Indian reserves, the cost of which is borne by the United States Office of Indian Affairs. It also cooperates with the United States Reclamation Service, and the United States Forest Service in collecting and publishing stream flow data. The funds for carrying on stream gaging work are not sufficient to meet the demand for such work, so that power companies, irrigation districts, cities, and individuals have contributed services of employees, instruments, material, equipment, and other help. The cost of hydrometric work carried on in the state during the present biennium is shown in the following table, the value of all services and other assistance rendered by cooperating parties being estimated when not known definitely:

#### ESTIMATED COST OF WATER RESOURCES INVESTIGATIONS IN THE STATE FOR THE BIENNIUM ENDING MARCH 31, 1917.

Washington Geological Survey.....	\$12,000
United States Geological Survey, gaging streams and power reports .....	\$12,000
United States Geological Survey, publishing water supply papers .....	13,730
United States Geological Survey, ground water investigations in Quincy Valley.....	1,650
United States Reclamation Service (approximate) ..	7,000
United States Office of Indian Affairs.....	6,700
United States Forest Service.....	1,060
District office rent furnished free of charge in the Federal Building at Tacoma.....	1,440
<b>Total Federal .....</b>	<b>43,580</b>
<b>Power companies, irrigation districts, cities and individuals .....</b>	<b>7,600</b>
<b>Grand Total .....</b>	<b>\$51,180</b>

Cooperation between the British Columbia Hydrometric Survey and the United States Geological Survey was instituted during the biennium. It consists of a plan to maintain jointly gaging stations on all important streams at or near the international boundary between Washington and British Columbia.

At present two such stations are being maintained; one on Clark Fork at Metaline Falls, Washington, and one on Columbia River at Trail, British Columbia. It is hoped that the work can be extended to cover Kettle, Okanogan, Similkameen, and Skagit rivers.

The chief objects of hydrometric surveys are to obtain accurate information regarding the amount of water that could be depended upon for irrigation and for power purposes. All of the water that can be secured by storage that is tributary to arid Washington will soon be needed for irrigation. The rapid industrial development of Western Washington demands the continued utilization of the available water power. The detailed investigations have been along two lines, viz.: establishment and maintenance of gaging stations, and a series of reports summarizing the power possibilities of the Cascade Range.

*Gaging Stations.*—As shown on the progress map, gaging stations have been maintained upon all of the principal streams of the state. Measurements of flow are frequently made, and daily records indicating height of water on substantially set gages are kept by local observers or by means of several types of water stage registers, which record the height of water on record sheets by clock driven mechanism. The measurements and gage heights make possible an estimate of the average amount of water flowing each day during the year. The water contributed by any stream varies considerably from day to day, season to season, and year to year, so that records for a series of years are necessary for properly designing hydraulic works. The records are particularly important during low water periods which occur on some streams in the early fall and on others in mid-winter. There are 90 gaging stations in operation at the close of the biennium, 34 of which are equipped with automatic water stage recording instruments.

The measurements, computed daily discharge, and summary of results are published annually by the United States Geological Survey in water supply papers. A sample of the data published for each station is given below for Skagit River at Sedro Woolley during the year ending September 30, 1916:

SKAGIT RIVER NEAR SEDRO WOOLLEY, WASH.

*Location.*—In NW $\frac{1}{4}$ , Sec. 36, T. 35 N., R. 4 E., at Northern Pacific Railway bridge, three-fourths mile below intake of Beatty's slough, 1 $\frac{1}{2}$  miles south of Sedro Woolley in Skagit County, 21 miles above mouth, and 32 miles below Baker River. Elevation at low water, about 25 feet.

*Drainage Area.*—2,930 square miles; measured on General Land Office map.

*Records Available.*—May 1, 1908, to September 30, 1916.

*Gage.*—Vertical staff on cribbing 100 feet above draw-span pier of Northern Pacific Railway bridge. Datum, extreme low water in Puget Sound. Temporary gage used when stage was below 37 feet; installed September 25, 1915, on downstream side of group of piles, 50 feet above third concrete pier (from left bank) of railway bridge. Gage read by E. J. Woods.

*Discharge Measurements.*—Made from highway bridge one-third mile above gage, Beatty's slough measured from highway bridge.

*Channel and Control.*—Gravel; shifts at high stages. Banks do not overflow except during extreme floods.

*Extremes of Discharge.*—Maximum stage recorded during the year, 46.5 feet at 3 p. m. June 18 (discharge, 63,800 second-feet); minimum stage recorded, 32.3 feet at 7 a. m. October 10-11 (discharge, 2,740 second-feet).

1908-1916: Maximum stage recorded, 56.1 feet November 30, 1909 (discharge, 96,100 second-feet); minimum stage recorded, 32.3 feet September 29-30 and October 10-11, 1915 (discharge, 2,740 second-feet).

*Ice.*—Stage-discharge relation seldom affected by ice.

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*Diversion.*—Beatty's slough carries from 1.5 per cent. of total flow at low stages to 8 per cent at high stages. Amount determined each visit and added to flow measured in river proper.

*Regulation.*—None.

*Accuracy.*—Stage-discharge relation changed during high water in June. Rating curve used before June 18 well defined between 3,500 and 18,000 second-feet, fairly well defined above and below; curve used after June 18 fairly well defined above 6,000 second-feet and poorly defined below. Gage read to half tenths daily; in addition crest gage heights observed or estimated. Practically no diurnal fluctuation. Results good except for a short interval in January and in February when they are only fair, due to ice.

DISCHARGE MEASUREMENTS OF SKAGIT RIVER NEAR SEDRO WOOLLEY,  
WASH., DURING THE YEAR ENDING SEPTEMBER 30, 1916.

Date	Made By—	GAGE HEIGHT (a)		Dis-charge
		Old Gage	Temporary Gage	
		Feet	Feet	Sec.-Ft.
Dec. 12	J. T. Hartson.....	36.40	36.35	15,500
Dec. 13	J. T. Hartson.....	35.85	35.80	12,800
June 22	C. O. Brown.....	40.00	(b)	31,800
June 28	C. O. Brown.....	42.95	(b)	48,800
Sept. 27	J. E. Stewart.....	34.97	35.49	10,900

(a) Observer's readings below 37 feet were taken from temporary gage; above 37 feet from old gage.

(b) Temporary gage submerged.

DAILY DISCHARGE, IN SECOND-FEET, OF SKAGIT RIVER NEAR SEDRO  
WOOLLEY, WASH., FOR THE YEAR ENDING SEPTEMBER 30, 1916.

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1...	2,960	81,900	8,150	7,220	4,920	11,800	13,200	19,200	20,000	32,200	25,300	13,700
2...	6,920	18,800	7,220	6,920	4,600	11,100	13,900	22,100	20,000	34,800	22,500	13,000
3...	7,530	18,000	8,460	6,320	4,890	10,400	14,300	30,000	21,700	41,200	21,600	14,100
4...	6,030	15,700	12,500	6,030	5,120	9,740	15,300	33,300	28,100	44,000	20,300	15,900
5...	4,400	16,100	12,100	5,740	5,340	8,780	16,800	32,800	30,000	35,800	19,800	13,700
6...	5,460	15,000	13,500	4,920	5,570	8,460	15,700	33,800	24,400	34,200	19,800	11,700
7...	3,900	12,500	13,200	4,920	5,800	8,150	15,000	33,800	22,600	30,700	20,300	10,300
8...	3,420	10,400	22,100	5,460	6,030	11,100	15,700	28,100	23,900	34,200	21,200	9,650
9...	3,420	10,100	46,700	5,190	5,460	22,100	16,100	25,300	30,000	42,900	21,600	10,300
10...	2,740	9,100	26,200	4,920	8,150	31,900	16,800	21,700	28,600	39,000	20,300	9,010
11...	2,740	8,460	19,200	3,900	12,500	27,600	18,400	19,200	24,400	36,800	20,700	8,080
12...	2,960	7,840	15,300	3,660	9,100	35,200	18,400	17,600	24,400	41,800	21,200	7,780
13...	5,190	6,920	13,500	3,660	7,220	38,200	16,800	16,800	29,000	41,800	21,600	7,780
14...	10,700	6,320	12,100	3,420	8,460	28,100	16,100	15,300	35,700	35,300	21,600	7,780
15...	8,460	6,030	10,400	3,190	22,600	23,000	18,400	15,300	42,700	29,600	20,700	7,180
16...	5,460	6,920	9,420	3,190	48,800	19,600	16,800	17,600	52,900	32,700	19,000	7,180
17...	4,400	7,530	9,100	3,350	46,700	19,200	15,700	20,000	61,200	37,400	15,500	7,480
18...	4,400	11,400	8,150	3,510	32,800	17,600	15,700	22,100	63,300	36,800	13,700	7,480
19...	9,100	14,600	7,840	3,670	26,700	16,100	15,300	22,600	59,900	31,700	13,000	7,480
20...	6,620	12,500	9,100	3,830	24,800	16,100	14,600	23,500	45,100	28,600	12,000	7,180
21...	10,400	9,420	12,100	3,990	23,600	21,700	14,300	23,000	41,200	32,200	11,000	7,180
22...	8,460	11,400	24,400	4,150	21,700	20,400	14,300	21,700	32,200	29,100	11,300	7,180
23...	7,220	11,400	17,200	10,400	20,000	21,700	13,200	19,200	35,300	29,600	12,300	7,780
24...	9,100	12,100	13,500	13,200	18,000	18,400	12,500	18,000	41,800	27,200	13,700	7,180
25...	11,100	10,100	14,300	8,460	15,700	16,800	12,800	18,000	42,900	27,200	15,200	6,800
26...	16,800	11,800	12,500	6,920	14,600	15,700	14,300	20,800	44,600	27,200	15,900	7,780
27...	22,100	11,100	11,100	5,740	14,300	18,400	17,200	23,900	52,400	23,900	15,900	12,000
28...	33,800	9,420	10,400	5,190	13,200	15,700	24,800	23,900	48,500	22,000	15,900	8,080
29...	30,900	9,740	9,420	5,190	12,500	15,000	22,100	23,500	46,800	22,000	15,500	6,600
30...	18,000	9,420	7,840	4,920	.....	13,500	19,600	21,300	34,800	22,500	15,200	6,020
31...	25,300	.....	7,220	4,920	.....	12,800	.....	20,000	.....	24,800	14,100	.....

NOTE.—Stage-discharge relation seriously affected by ice gorge one-half mile below gage Jan. 17-21, discharge interpolated. Gage heights doubtful on account of ice at gage Feb. 3-7, discharge interpolated.

MONTHLY DISCHARGE OF SKAGIT RIVER NEAR SEDRO WOOLLEY, WASH.,  
FOR THE YEAR ENDING SEPTEMBER 30, 1916.  
(Drainage area, 2,930 square miles.)

MONTH	DISCHARGE IN SECOND-FEET				RUN-OFF	
	Maximum	Minimum	Mean	Per Square Mile	Depth in Inches on Drainage Area	Total in Acre-Feet
October .....	33,800	2,740	9,680	3.30	3.80	595,000
November .....	31,900	6,030	11,700	3.99	4.45	696,000
December .....	46,700	7,220	13,700	4.68	5.40	842,000
January .....	13,200	3,190	5,360	1.83	2.11	330,000
February .....	48,800	4,660	16,000	5.46	5.89	920,000
March .....	38,200	8,150	18,200	6.21	7.16	1,120,000
April .....	24,800	12,500	16,100	5.49	6.12	958,000
May .....	33,800	15,300	22,700	7.75	8.94	1,400,000
June .....	63,300	20,000	36,900	12.6	14.06	2,200,000
July .....	44,000	22,000	32,600	11.1	12.80	2,000,000
August .....	25,300	11,000	17,700	6.04	6.96	1,090,000
September .....	15,900	6,020	9,120	3.11	3.47	543,000
The year.....	63,300	2,740	17,400	5.94	81.16	12,700,000

*Cascade Power Reports.*—Through cooperative arrangements with the State Board of Geological Survey in 1909, the federal Survey adopted its first comprehensive plan for giving the public accurate data concerning water power resources. More recently similar work has been instituted in Oregon. Progress has been hampered considerably due to lack of sufficient base data and the need of continuing stream flow observations over a series of years in order to insure dependable estimates of water supply. Surveys have been run along the portions of the larger streams in the Cascade Range. Reservoir sites which appear to offer favorable storage opportunities for increasing the low water flow have been surveyed and a large mass of information bearing upon the feasibility of hydroelectric projects has been collected.

The scheme followed in analyzing the power resources of the Cascades consists of assembling the estimates for a group of streams within a relatively small section of the range. It is proposed to publish the estimates in a series of seven reports published by the United States Geological Survey as water supply papers. The areas to be covered in the seven units are shown on the progress map attached.

The first report is Water Supply Paper 253 and is entitled "Water Powers of the Cascade Range, Part I, Southern Washington." The power possibilities of Klickitat, White Salmon, Little White Salmon, Lewis and Toutle rivers are summarized.

The second report is Water Supply Paper 313 and is entitled "Water Powers of the Cascade Range, Part II." The power possibilities of Cowlitz, Nisqually, Puyallup, White, Cedar and Green rivers are summarized. This report also includes a discussion of the hydroelectric market conditions in the Puget Sound region.

The third report is Water Supply Paper 369 and is entitled "Water Powers of the Cascade Range, Part III, Yakima Basin." The summaries were more difficult to compile than for any of the series on account of the necessity of taking into consideration the ultimate use of stored water for irrigation in the Yakima Valley.

The fourth report has not as yet been published, but will be entitled "Water Powers of the Cascade Range, Part IV, Wenatchee and Entiat basins." The relative water power resources in the Wenatchee basin with and without the proposed Quincy Valley irrigation scheme in operation will be summarized and the flow available for the Quincy project through utilizing storage in Wenatchee Lake reservoir will be described.

All of the field data have been collected for the fifth unit and considerable work has been done toward compiling the data.

Practically all of the surveys have been completed for the sixth and seventh units, and most of the field reconnaissance for the sixth unit has been finished. Gaging stations are being maintained in each to determine the available water supply.

#### GEOLOGICAL SURVEYS.

*Mineral Resources.*—The State Geological Survey, since 1911, has cooperated with the United States Geological Survey in the collection of statistics regarding the mineral production of Washington. It is a matter of great importance to the state that such statistics be secured covering accurately the entire mineral output, because of the bearing this must have upon

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the establishment of industrial enterprises. The accompanying table gives a summary of the principal mineral products of Washington for the ten-year period from 1906 to 1915, inclusive. While the production is already large, and constantly growing, it is capable of a very much greater extension when the economic minerals are investigated and made better known.

The statistics covering the mineral resources of the state should be published annually. The report for 1912, known as "Bulletin 11," gives a description of the principal localities where different mineral products are obtained, with a list of producers and a statement covering the output. This bulletin was accompanied by an outline map of the state wherein, by a system of symbols and colors, all varieties of mineral products were shown in the localities where they are obtained.

MINERAL PRODUCTION OF WASHINGTON FROM 1906 TO 1915, INCLUSIVE (a).

	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915
<b>NON-METALLIC PRODUCTS</b>										
Coal .....	\$5,908,434	\$7,679,801	\$6,690,412	\$9,158,999	\$9,794,465	\$8,174,170	\$8,042,871	\$9,243,137	\$6,751,511	\$5,276,299
Clay products .....	1,499,884	1,921,934	2,104,289	3,000,486	3,023,854	2,861,758	2,888,870	2,370,226	1,809,491	1,460,051
Portland cement .....	459,975	(b) 214,500	(b) 396,000	707,186	1,031,704	1,496,807	2,012,785	2,853,260	1,870,079	1,790,499
Granite .....	169,500	595,352	870,944	732,578	642,692	1,345,551	809,201	(c) 632,915	72,079	260,688
Basalt .....	49,192	295,685	464,587	335,470	488,551	301,843	844,476	33,710	1,068,042	1,452,869
Sandstone .....	59,985	62,317	31,660	38,269	36,186	32,478	20,370	62,913	10,585	11,560
Limestone .....	347,924	238,568	228,353	282,628	267,785	228,933	234,832	219,163	178,945	189,200
Marble .....	10,800	10,820	13,650	15,958	12,571	14,654	17,542	18,834	28,777	11,703
Mineral waters .....	144,725	179,800	261,531	423,425	481,569	319,760	845,289	885,886	324,628	211,480
Sand and gravel .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Diatomaceous earth .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Totals .....	\$8,650,419	\$11,165,677	\$11,061,426	\$14,825,308	\$15,689,657	\$14,775,354	\$14,216,226	\$16,507,081	\$12,564,572	\$10,712,624
<b>METALLIC PRODUCTS</b>										
Gold .....	\$921,648	\$262,300	\$253,700	\$262,051	\$788,145	\$847,677	\$680,964	\$695,975	\$557,173	\$391,419
Silver .....	30,738	55,400	46,400	41,334	110,896	129,204	254,326	200,048	146,468	129,709
Copper .....	45,980	24,453	21,411	33,167	11,038	39,776	179,192	147,888	168,571	178,662
Lead .....	52,787	29,786	32,844	12,414	58,180	38,186	5,732	8,969	2,555	13,875
Totals .....	\$950,583	\$371,989	\$354,355	\$448,966	\$968,249	\$1,056,017	\$1,120,214	\$1,063,195	\$800,767	\$713,665
Grand Totals .....	\$9,000,992	\$11,587,616	\$11,415,781	\$15,274,274	\$16,657,906	\$15,681,971	\$15,336,450	\$17,560,216	\$13,374,339	\$11,426,289

(a) Compiled from Mineral Resources U. S. Geological Survey.

(b) Approximate production.

(c) Heretofore included in granite totals.

*Office Work.*—The office work of the Geological Survey becomes increasingly heavy from year to year. Constant inquiries come to the office in regard to the mineral resources of every portion of the state. Prospective settlers and others are very desirous of accurate information regarding the climatic and soil conditions of those regions in which they may plan to make their homes. Manufacturers are desirous before coming to Washington of knowing the nature of the fuel supply and the variety of crude materials of a mineral character which may be obtained for manufacturing purposes. On the whole the work of the State Geological Survey is carried on at a minimum of expense because a very large part of the work, especially the office work, is done by men who do not receive any compensation for that purpose out of the funds of the Survey.

Within the biennium a report on The Coal Fields of Kittitas County, known as Bulletin 9, has been printed. This is the third of the county reports on our coal fields, bulletins on King and Pierce counties having been issued in previous years. There has lately been printed, also, a report on The Tertiary Formations of Western Washington, known as Bulletin 13. This publication describes the bed rock formations of that part of the state to the westward of the foothills of the Cascade Mountains. The report is accompanied by geologic maps which represent not only the areal extent of the various kinds of rocks, but also the structure of the formations, the dip and strike of the beds, and in a general way indicate the best places for prospecting for gas and oil. The possible occurrence of these economic products at the different localities of the extensive area are carefully considered.

FINANCIAL STATEMENT.

TOPOGRAPHIC AND HYDROGRAPHIC SURVEYS.

U. S. Geological Survey:	
Allotment for cooperation 1915-17.....	\$35,000 00
Expenditures to December 1, 1916.....	30,488 06
	\$4,511 94
State Geological Survey:	
Appropriation for 1915-17.....	\$35,000 00
Expenditures to December 1, 1916.....	30,111 43
	\$4,888 57

## RECOMMENDATIONS.

## APPROPRIATIONS REQUESTED.

For topographic and hydrometric surveys (conditioned upon a similar sum being expended in the state by the United States Geological Survey).....	\$35,000
For Geological Surveys.....	20,000

## TOPOGRAPHIC SURVEYS.

For some time the greatest demand for topographic surveys has come from the arid and semi-arid regions of the state where the land may be put to its greatest use only by irrigation, and where topographic maps are invaluable for engineering work of this character. Such maps are also requested in those portions of Washington where the country is being rapidly settled, and in certain mountainous areas where large water-power projects are under consideration. Urgent requests are now on file for topographic surveys of Asotin, Eatonville, Fort Simcoe, Othello, Olympia, Pomeroy, Port Angeles, Sultan and Yakima quadrangles.

In the past eight years level lines or profiles have been run along all the streams of the Cascade Mountains, except the three forks of the Nooksack River. This has been done as a necessary part of the problem of determining with accuracy the total hydro-electric power of the rivers of the Cascades. In the next biennium the Nooksack River should be surveyed, and river profiles begun on the streams of the Olympic Mountains. When the latter are completed it will then be possible to publish detailed reports on the water power resources of the entire state.

## HYDROMETRIC SURVEYS.

As indicated on the progress map accompanying this report, gaging stations are maintained on a large number of the rivers where information is very necessary as to the total amount of water available for municipal supplies, irrigation and power. The number of stations should be increased rather than diminished. Each added year of gaging at any station makes the records that much more valuable. The demand for accurate information regarding our water resources grows stronger with

each biennium. It is recommended that the usual appropriation for this work be made so that cooperation with the Federal Government may be continued.

#### GEOLOGICAL SURVEYS.

The sum of twenty thousand dollars, the same amount as appropriated by the legislatures of 1909, 1911 and 1913, is requested for geological surveys, in order that certain lines of work now under way may be completed and some important new work may be begun.

*Uncompleted Reports.*—In former years a large amount of field and office work has been done upon certain reports which have not yet been published, because the money has not been available. It is urgent that funds be provided so that such bulletins may be printed at once and their contents made available for use. The field work has been completed, and the manuscript partly prepared, for a report upon the coal deposits of Whatcom and Skagit counties. The field work has been about two-thirds completed for a report upon the coal fields of Thurston, Lewis and Cowlitz counties. When these reports are through the press the State Geological Survey will have issued detailed bulletins covering all of the coal resources of the state.

Some time ago a bulletin was published on the surface geology of the Puget Sound basin. Since that time the field work has been completed and the manuscript prepared for a similar report upon the surface geology of that portion of the state south of the latitude of Tenino, and west of the foothills of the Cascades. This report can be sent to the printer as soon as an appropriation is available.

*Soil Surveys.*—In earlier years soil surveys have been made of nearly all the logged-off lands of Western Washington, besides similar surveys and reports upon the Quincy Valley country, Stevens and Franklin counties, in Eastern Washington. In all soil surveys cooperation has been afforded by the United States Bureau of Soils, the Federal Bureau usually assuming about three-fourths of the expense of the field work besides all

the cost of printing. The reports of the soil surveys have been in large demand from the agriculturists, commercial bodies, prospective settlers, county assessors, and all others who desire to know the facts about the soil conditions in various parts of the state. At the present time requests are on file for soil surveys in various sections of Washington where this work has not been done.

*Road Materials.*—In the large road construction program now being carried out by the state and the various counties, it is a matter of the greatest concern that the very best quality of materials be used. In most states it is the business of the Geological Survey to locate, map, and describe all the materials suitable for road building. Repeated requests have come from county commissioners, county engineers, and road contractors that such a detailed survey be made in Washington.

It is therefore recommended that provision be made for a complete field investigation of the deposits of sand and gravel suitable for road surfacing and for concrete construction as well; and that the field studies should include a search for all available occurrence of limestone and clay, of value in cement making, which have not been described in earlier survey reports. It is proposed that extensive lots of samples be collected in the field, and that these be carefully tested in the most practical way, so that the relative values of all samples secured can be accurately determined. It would be the plan to publish full reports and maps covering all the results of the field investigations and the practical tests that were made, and place these in the hands of all engineers and others who are charged with the responsibility of maintaining the highest possible standards in road construction.

*Surveys of Metal Mining Districts.*—In addition to the detailed surveys already made of the best known districts, there are many requests for reconnaissance surveys of the scattered mining sections, whereby the varieties of bed-rock, the important minerals, and the character of the ore deposits may be determined and described. For the next biennium surveys of the mining districts in Ferry, Stevens and Pend Oreille counties should

be made. Such surveys are of very great service to the mining men who are giving their time and money to the development of one of the state's resources. It is of great value to the miner, as well as to the investor, and to the state at large, that the truth in regard to the quality and quantity of the ore bodies should be made known.

*Report on Mineral Industries.*—Any information bearing upon the production of different minerals in different counties and other portions of the state is always in much demand. It seems necessary to keep this information in such form that it may be given out regularly and be revised as often as desirable. At least once a year reports and maps should be issued which set forth the localities where different mineral products may be obtained, along with the names of all producers, and with accurate statistics in regard to the output of each particular mineral concerned. Such information is very greatly desired by manufacturers and others who have occasion to use in any way whatsoever those minerals that are of economic importance.

*Topographical Map.*—There is constant inquiry for a map which will show by a system of contours, or by a series of lines, the elevations of various portions of the state. By utilizing the base map which has already been prepared, and by compiling the data regarding elevations throughout the state, it will be possible to prepare a map which will give the information most needed. Such a map should be printed in colors, the black referring to culture, the blue giving the water bodies, and a series of brown shades or tints which will give the variation in elevation from sea level to the tops of the highest mountains.

*Geological Map.*—More requests have come for a geological map of the state than for any other one thing. With the base map now available it is desirable that the boundaries of the different geological formations should be entered thereon and a complete geological map of the state be prepared as early as possible. This has been very generally done by other states and Washington will be one of the last to prepare such a map. The cost of preparation of such a map is not excessive, and its value to our citizens generally would repay the cost many fold.



**PUBLICATIONS**  
OF THE  
**WASHINGTON GEOLOGICAL SURVEY**

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**ADDRESS**  
**STATE LIBRARIAN**  
**OLYMPIA, WASHINGTON**

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**Volume 1.**—Annual Report for 1901. Part 1, Creation of the State Geological Survey, and An Outline of the Geology of Washington, by Henry Landes; part 2, The Metalliferous Resources of Washington, Except Iron, by Henry Landes, William S. Thyng, D. A. Lyon and Milnor Roberts; part 3, The Non-Metalliferous Resources of Washington, Except Coal, by Henry Landes; part 4, The Iron Ores of Washington, by S. Shedd, and the Coal Deposits of Washington, by Henry Landes; part 5, The Water Resources of Washington, by H. G. Byers, C. A. Ruddy and R. E. Heine; part 6, Bibliography of the Literature Referring to the Geology of Washington, by Ralph Arnold. Out of print.

**Volume 2.**—Annual Report for 1902. Part 1, The Building and Ornamental Stones of Washington, by S. Shedd; part 2, The Coal Deposits of Washington, by Henry Landes and C. A. Ruddy. Postage 20 cents.

**Bulletin 1.**—Geology and Ore Deposits of Republic Mining District, by Joseph B. Umpleby. Bound in cloth; price 35 cents.

**Bulletin 2.**—The Road Materials of Washington, by Henry Landes. Bound in cloth; price, 60 cents.

**Bulletin 3.**—The Coal Fields of King County, by Geo. W. Evans. Bound in cloth; price, 75 cents.

**Bulletin 4.**—The Cement Materials of Washington, by S. Shedd. Bound in cloth; price, 75 cents. Paper cover; price, 40 cents.

**Bulletin 5.**—Geology and Ore Deposits of the Myers Creek and Orville-Nighthawk Districts, by Joseph B. Umpleby. Bound in cloth; price, 50 cents.

**Bulletin 6.**—Geology and Ore Deposits of the Blewett Mining District, by Charles E. Weaver. Bound in cloth; price, 50 cents.

**Bulletin 7.**—Geology and Ore Deposits of the Index Mining District, by Charles E. Weaver. Bound in cloth; price, 50 cents.

**Bulletin 8.**—Glaciation of the Puget Sound Region, by J. Harlen Bretz. Bound in cloth; price, 60 cents. Paper cover; price, 35 cents.

**Bulletin 9.**—The Coal Fields of Kittitas County, by E. J. Saunders. Paper cover; price, 40 cents.

**Bulletin 10.**—The Coal Fields of Pierce County, by Joseph Daniels. Bound in cloth; price, 60 cents. Paper cover; price, 40 cents.

**Bulletin 11.**—The Mineral Resources of Washington, with Statistics for 1912, by Henry Landes. Paper cover; price, 25 cents.

**Bulletin 12.**—Bibliography of Washington Geology and Geography, by Gretchen O'Donnell. Paper cover; price, 25 cents.

**Bulletin 13.**—The Tertiary Formations of Western Washington, by Charles E. Weaver. Paper cover; price, 40 cents.

**Bulletin 14.**—The Quincy Valley Irrigation Project, by Henry Landes, A. W. Mangum, H. K. Benson, E. J. Saunders, and Joseph Jacobs. Paper cover; price, 20 cents.

**Bulletin 15.**—A Preliminary Report on the Tertiary Paleontology of Western Washington, by Chas. E. Weaver. Paper cover; price, 20 cents.

**Bulletin 16.**—Geology and Ore Deposits of the Covada Mining District, by Charles E. Weaver. Paper cover; price, 25 cents.

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PUBLICATIONS OF THE U. S. GEOLOGICAL SURVEY, IN CO-  
OPERATION WITH THE WASHINGTON  
GEOLOGICAL SURVEY.

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(For copies of these publications address the Director, U. S. Geological Survey, Washington, D. C. Water-Supply papers may also be obtained, upon request, and free of charge, from the U. S. Geological Survey district office, 406 Federal Building, Tacoma, Washington.)

TOPOGRAPHIC MAPS OF THE FOLLOWING QUADRANGLES.

Arlington, Beverly, Cedar Lake, Chehalis, Coyote Rapids, Hoquiam, Malaga, Moses Lake, Mount Vernon, Ocosta, Pasco, Priest Rapids, Prosser, Quincy, Red Rock, Wallula, Wenatchee, Winchester.

**Power Reports.**

Water-Supply Paper No. 253: Water Powers of the Cascade Range, Part I, Southern Washington.

Water-Supply Paper No. 313: Water Powers of the Cascade Range, Part II, Southeastern Washington, Puget Sound Region.

Water-Supply Paper No. 369: Water Powers of the Cascade Range, Part III, Yakima Basin.

Water-Supply Paper No. —: Water Powers of the Cascade Range, Part IV, Wenatchee and Entiat basins. In preparation.

**River Profiles.**

Water-Supply Paper No. 346: Profile Surveys of Clark Fork of Columbia River.

Water-Supply Paper No. 366: Profile Surveys of Snoqualmie, Sultan and Skykomish rivers.

Water-Supply Paper No. 368: Profile Surveys of Wenatchee River and tributaries.

Water-Supply Paper No. 376: Profile Surveys, Chelan and Methow basins.

Water-Supply Paper No. 377: Profile Surveys, Spokane and John Day basins.

Water-Supply Paper No. 419: Profile Surveys in Skagit River Basin.

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**Annual Stream-Flow Reports.**

Water-Supply Paper No. 272: Surface Water Supply of the United States, North Pacific Coast, 1909.

Water-Supply Paper No. 292: Surface Water Supply of the United States, North Pacific Coast, 1910.

Water-Supply Paper No. 312: Surface Water Supply of the United States, North Pacific Coast, 1911.

Water-Supply Paper No. 332: Surface Water Supply of the United States, North Pacific Coast, 1912.

Water-Supply Paper No. 340. Gaging stations and publications on water resources 1885-1913.

Water-Supply Paper No. 362: Surface Water Supply of the United States, North Pacific Coast, 1913.

Water-Supply Paper No. 392: Surface Water Supply of the United States, North Pacific Coast, 1914.

Water-Supply Paper No. 412: Surface Water Supply of the United States, North Pacific Coast, 1915. In preparation.

Water-Supply Paper No. 442: Surface Water Supply of the United States, North Pacific Coast, 1916. In preparation.

**Qualitative Report.**

(Principally in cooperation with State Board of Health.)

Water-Supply Paper No. 339: Quality of Surface Waters of Washington.

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**PUBLICATIONS OF THE U. S. DEPARTMENT OF AGRICULTURE,  
BUREAU OF SOILS, IN COOPERATION WITH THE  
WASHINGTON GEOLOGICAL SURVEY.**

(For copies of these publications address one of the members of congress from Washington.)

Reconnaissance Soil Survey of the Eastern Part of Puget Sound Basin.

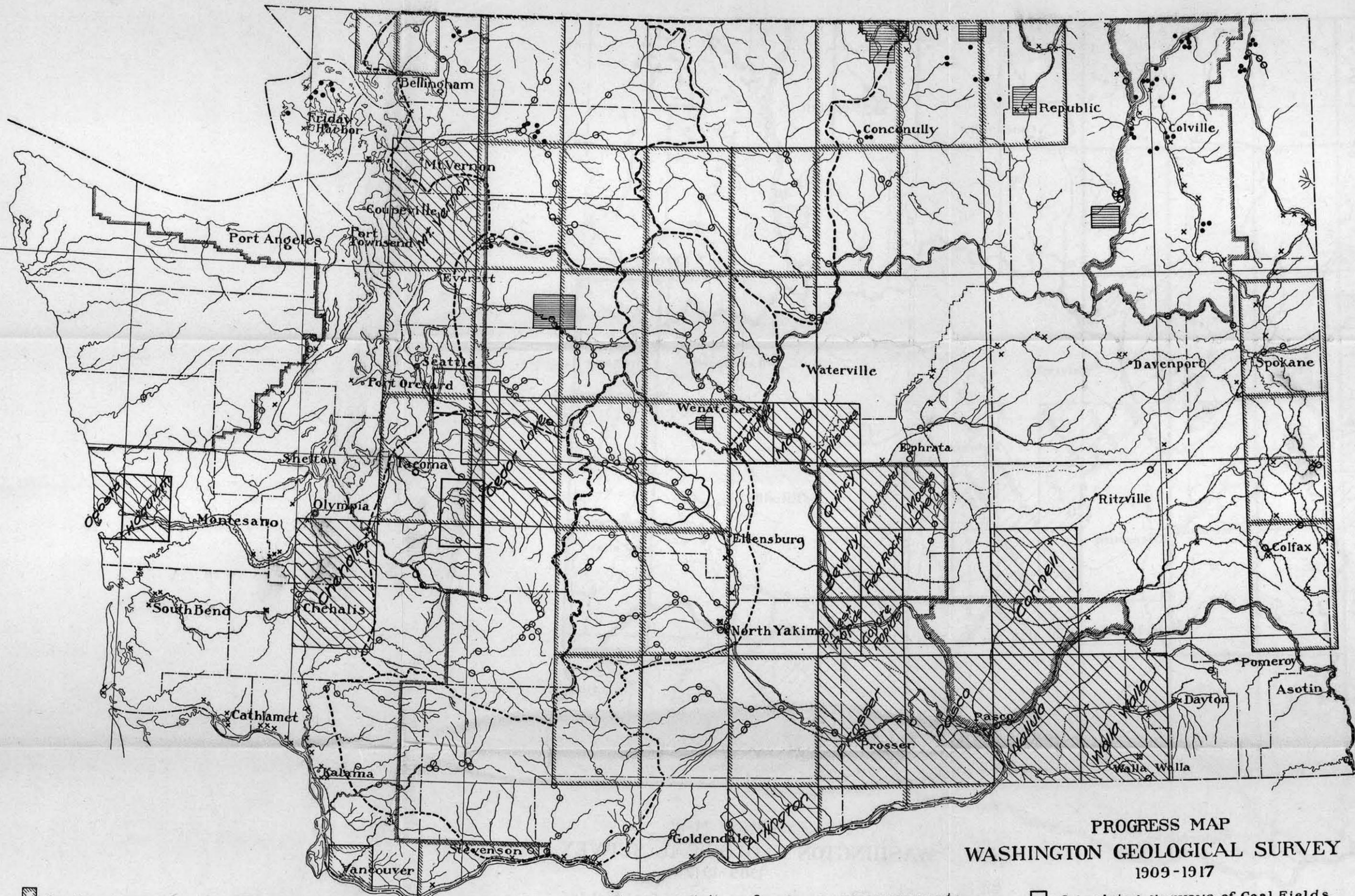
Reconnaissance Soil Survey of the Western and Southern Parts of the Puget Sound Basin.

Reconnaissance Soil Survey of Southwestern Washington.

Reconnaissance Soil Survey of the Quincy Area.

Reconnaissance Soil Survey of Stevens County.

Reconnaissance Soil Survey of Franklin County. In press.



PROGRESS MAP  
 WASHINGTON GEOLOGICAL SURVEY  
 1909-1917

- ▨ Quadrangles surveyed by U.S. Geological Survey previous to 1909.
- ▩ Quadrangles surveyed under co-operation during 1909-17
- x Locations of rock deposits tested for use in road building.
- Gauging stations for stream measurements.
- Areas covered by Water Power Reports.
- Locations of materials tested for making cement.
- Completed Surveys of Coal Fields.
- ▨ Metal Mining Districts.
- ▩ Soil Surveys.
- ▣ State quarries located for road building:

# TOPOGRAPHY

U.S. GEOLOGICAL SURVEY  
GEORGE OTIS SMITH  
DIRECTOR

STATE OF WASHINGTON  
M.E. HAY, GOVERNOR  
HENRY LANDES, STATE GEOLOGIST

WASHINGTON  
(GRAYS HARBOR COUNTY)  
HOQUIAM QUADRANGLE



R.B. Marshall, Chief Geographer.  
T.G. Gerdine, Geographer in charge.  
Topography by Chas. Hartmann, Jr., G.L. Hagman,  
Ralph R. Randall, Geo. H. King, Jr., and D.H. Watson.  
Control by Coast and Geodetic Survey, L.F. Biggs,  
and G.L. Hagman.  
Surveyed in 1911-1912.  
SURVEYED IN COOPERATION WITH THE STATE OF WASHINGTON.

Scale 1:62500  
1 2 3 4 5 Miles  
1 2 3 4 5 Kilometers  
Contour interval 25 feet.  
Datum is mean sea level.

TRUE NORTH  
MAGNETIC NORTH  
APPROXIMATE MEAN DECLINATION 1912.  
Edition of May 1915.  
HOQUIAM

# THE TOPOGRAPHIC MAPS OF THE UNITED STATES

The United States Geological Survey is making a topographic atlas of the United States. This work has been in progress since 1882, and more than 38 per cent of the area of the country, excluding outlying possessions, has now been mapped. The areas mapped are widely distributed, every State being represented, as shown on the progress maps accompanying each annual report of the Director.

This atlas is being published in sheets of convenient size, about 16½ by 20 inches. The four-sided area of land represented on an atlas sheet is bounded by parallels and meridians and is called a *quadrangle*. The quadrangles mapped cover 1° of latitude by 1° of longitude, 30' of latitude by 30' of longitude, 15' of latitude by 15' of longitude, or smaller areas, the size of the area mapped depending on the scale used. Several scales are employed. The smallest scale, that used for quadrangles covering 1°, is 1:250,000, or very nearly 4 miles to an inch—that is, 4 linear miles on the ground is represented by 1 linear inch on the map. This scale is used for maps of the desert regions and some other parts of the far West. For the greater part of the country, which is mapped by quadrangles covering 30', a larger scale, 1:125,000, or about 2 miles to an inch, is employed. A still larger scale, 1:62,500, or about a mile to an inch, is used for quadrangles covering 15', the unit selected for mapping thickly settled or industrially important areas. A fourth scale, 1:31,250, or one-half mile to an inch, is employed for maps that are to be used in connection with irrigation or drainage, and a few maps of mining districts are published on still larger scales.

A topographic survey of Alaska has been in progress since 1898 and nearly 30 per cent of its entire area has now been mapped. One-third of the area mapped, or 10 per cent of the Territory, has been covered only by reconnaissance work, the results of which have been mapped on a scale of about 10 miles to an inch. The maps of nearly all the remaining two-thirds of the surveyed area have been published on a scale of 1:250,000, or about 4 miles to an inch. These maps are large, each representing 2° of latitude by 4° of longitude. A few areas that are of economic importance, aggregating about 3,000 square miles, have been surveyed in greater detail and mapped on a scale of 1:62,500, or about a mile to an inch.

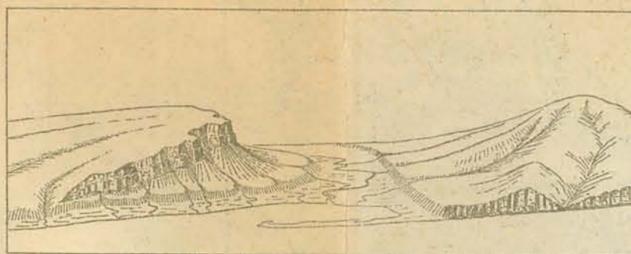
A survey of the Hawaiian Islands was begun in 1910 and the resulting maps are being published on a scale of 1:62,500.

The features shown on these atlas sheets or maps may be classed in three groups—(1) *water*, including seas, lakes, rivers, canals, swamps, and other bodies of water; (2) *relief*, including mountains, hills, valleys, and other elevations and depressions; (3) *culture* (works of man), such as towns, cities, roads, railroads, and boundaries. The conventional signs used for these features are shown below, with explanations. Variations appear on some earlier maps.

All water features are printed in *blue*, the smaller streams and canals in full blue lines and the larger streams, lakes, and the sea in blue water-lining. Intermittent streams—those whose beds are dry at least three months in the year—are shown by lines of dots and dashes.

Relief is shown by contour lines in *brown*. A contour on the ground passes through points that have the same altitude. One who follows a contour will go neither uphill nor downhill but on a level. The contour lines on the map show not only the shapes of the hills, mountains, and valleys but also their elevations. The line of the sea coast itself is a contour line, the datum or zero of elevation being mean sea level. The contour at, say, 20 feet above sea level would be the shore line if the sea were to rise or the land to sink 20 feet. On a gentle slope this contour is far from the present coast; on a steep slope it is near the coast. Where successive contour lines are far apart on the map they indicate a gentle slope; where they are close together they indicate a steep slope; and where they run together in one line they indicate a cliff.

The manner in which contour lines express altitude, form, and grade is shown in the figure below.



The sketch represents a river valley between two hills. In the foreground is the sea, with a bay that is partly inclosed by a hooked sand bar. On each side of the valley is a terrace into which small streams have cut narrow gullies. The hill on the right has a rounded summit and gently sloping spurs separated by ravines. The spurs are truncated at their lower ends

by a sea cliff. The hill on the left terminates abruptly at the valley in a steep scarp. It slopes gradually back away from the scarp and forms an inclined table-land, which is traversed by a few shallow gullies. On the map each of these features is indicated, directly beneath its position in the sketch, by contour lines.

The contour interval, or the vertical distance in feet between one contour and the next, is stated at the bottom of each map. This interval differs according to the character of the area mapped; in a flat country it may be as small as 5 feet; in a mountainous region it may be 250 feet. Certain contour lines, every fourth or fifth one, are made heavier than the others and are accompanied by figures stating elevation above sea level. The heights of many points, such as road corners, summits, surfaces of lakes, and bench marks, are also given on the map in figures, which express the elevations to the nearest foot only. More exact elevations of bench marks, as well as geodetic coordinates of triangulation stations, are published in bulletins issued by the Geological Survey. A bulletin pertaining to any State may be had on application.

The works of man are shown in *black*, in which color all lettering also is printed. Boundaries, such as those of a State, county, city, land grant, township, or reservation, are shown by continuous or broken lines of different kinds and weights. Public and through roads are shown by fine double lines; private and poor roads by dashed double lines; trails by dashed single lines.

Each quadrangle mapped for the topographic atlas is designated by the name of a principal town or of some prominent natural feature within the quadrangle, and on the margins of the maps are printed the names of adjoining quadrangles for which atlas sheets have been published or are in preparation. The sheets are sold at 10 cents each in lots of less than 50 copies or at 6 cents each in lots of 50 or more copies, whether of the same or of different sheets.

The topographic map is the base on which the geology and the mineral resources of a quadrangle are represented, the maps showing these features being bound together, with a description of the quadrangle, to form a folio of the Geologic Atlas of the United States. Circulars showing by index maps the published topographic atlas sheets and geologic folios covering any State or region will be sent free on application.

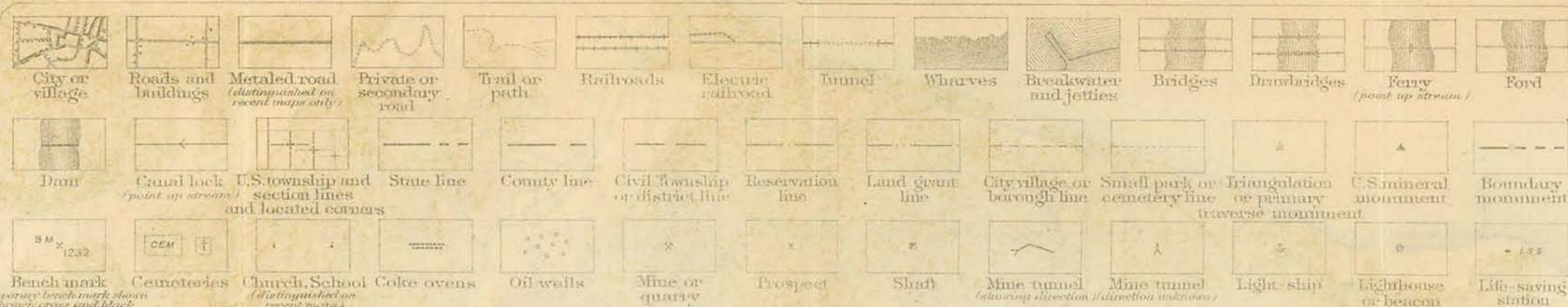
Applications for maps or folios should be accompanied by cash—the exact amount—or by post-office money order (not postage stamps), and should be addressed to—

THE DIRECTOR,  
United States Geological Survey,  
Washington, D. C.

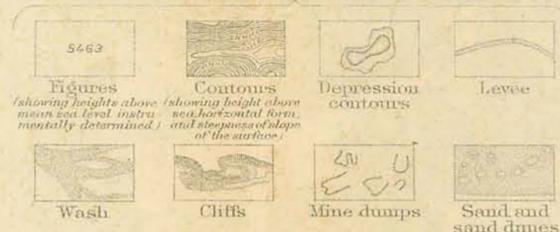
January, 1915.

## CONVENTIONAL SIGNS

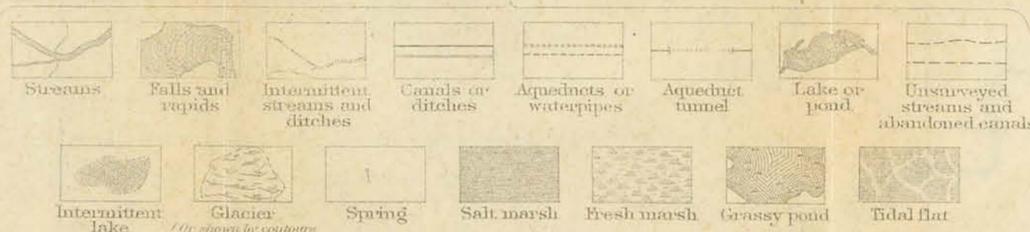
### CULTURE (printed in black)



### RELIEF (printed in brown)



### WATER (printed in blue)



### WOODS (when shown, printed in green)